Claims

What is claimed is:

[c1] A method for designing a drill bit, comprising:

defining parameters for a simulation of the drill bit drilling in an earth formation, wherein the parameters comprise at least bit design parameters;

executing the defined simulation;

obtaining radial forces resulting from the executing of the defined simulation;

applying a criterion to the obtained radial forces; and

adjusting one of the at least bit design parameters in response to the applying of the criterion.

[c2] The method of claim 1, wherein the parameters further comprise performance parameters, environment parameters, and simulation parameters.

[c3] The method of claim 2, wherein the performance parameters comprise drilling parameters.

[c4] The method of claim 2, wherein environment parameters comprise cutting element interaction data and bottom hole geometry data.

[c5] The method of claim 1, wherein the executing the simulation comprises:

rotating the drill bit;

calculating a new location of a cutting element on the drill bit;

determining the interference between the cutting element and the earth formations at the new location; and

calculating a radial force acting on the earth formations based on the interference at the new location.

[c6] The method of claim 1, wherein the drill bit is a roller cone drill bit.

[c7] The method of claim 6, wherein the bit design parameters comprises at least one of a group consisting of a cone profile, a cone axis offset, a number of cutting elements on each cone, a location of a cutting element of the drill bit, a size of a cutting element of the drill bit, a shape of a cutting element of the drill bit, and an orientation of a cutting element of the drill bit.

[c8] The method of claim 1, wherein the drill bit is a fixed cutter drill bit.

[c9] The method of claim 8, wherein the bit design parameters comprises at least one of a group consisting of a cutter location, a cutter orientation, a cutter size, a cutter shape, and a cutter bevel size, a bit profile, a bit diameter, a number of blades on the bit, a blade geometry, a blade location, a junk slot area, and a bit axial offset.

[c10] The method of claim 1, wherein the applying the criterion to the radial forces comprises:

summing a magnitude of the radial forces with respect to the direction to generate a sum of radial forces;

comparing the sum of radial forces to an applied weight-on-bit; and

generating a ratio between the sum of the radial forces and the applied weight-on-bit.

[c11] The method of claim 10, wherein the ratio of the sum of the radial forces to the applied weight-on-bit is no more than about 0.20.

[c12] The method of claim 10, wherein the ratio of the sum of the radial forces to the applied weight-on-bit is no more than about 0.10.

[c13] The method of claim 10, wherein the ratio of the sum of the radial forces to the applied weight-on-bit is no more than about 0.05.

[c14] The method of claim 1, wherein the applying the criterion comprises:

plotting a magnitude of the radial forces with respect to at least one selected from a group of direction of force, frequency of occurrence, time, to generate a radial force plot.

[c15] The method of claim 14, wherein the radial force plot comprises a polar plot of magnitude and direction of resultant radial force.

[c16] The method of claim 15, wherein the polar plot indicates that the resultant force is less than a predetermined value for a selected percentage of the time during simulated drilling.

[c17] The method of claim 16, wherein the selected percentage of time during simulated drilling is 70%.

[c18] The method of claim 14, wherein the radial force plot comprises a chart plot of resultant radial force.

[c19] The method of claim 18, wherein the polar plot indicates that the resultant force is less than a predetermined value for a selected percentage of the time during simulated drilling.

[c20] The method of claim 19, wherein the selected percentage of time during simulated drilling is 70%.

[c21] The method of claim 14, wherein the radial force plot comprises a box-whisker plot of resultant radial force.

[c22] The method of claim 21, wherein the polar plot indicates that the resultant force is less than a predetermined value for a selected percentage of the time during simulated drilling.

[c23] The method of claim 22, wherein the selected percentage of time during simulated drilling is 70%.

[c24] A method for designing a bottomhole assembly, comprising:

defining parameters for a simulation of a drilling tool assembly drilling in an earth formation, wherein the parameters comprise at least bottomhole assembly design parameters;

executing the defined simulation;

obtaining radial forces resulting from the executing of the defined simulation;

applying a criterion to the obtained radial forces to evaluate the drill tool assembly performance; and

adjusting one of the at least bottomhole assembly design parameters in response to the applying of the criterion.

[c25] The method of claim 24, wherein the applying the criterion to the radial forces comprises:

summing a magnitude of the radial forces with respect to the direction to generate a sum of radial forces;

comparing the sum of radial forces to an applied weight-on-bit; and

generating a ratio between the sum of the radial forces and the applied weight-on-bit.

[c26] The method of claim 24, wherein the applying the criteria comprises:

plotting a magnitude of the radial forces with respect to at least one selected from a group of direction of force, frequency of occurrence, time, to generate a radial force plot.

[c27] The method of claim 26, wherein the radial force plot comprises a polar plot of resultant radial force.

[c28] The method of claim 27, wherein the polar plot indicates that the resultant force is less than a predetermined value for a selected percentage of the time during simulated drilling.

[c29] The method of claim 28, wherein the selected percentage of time during simulated drilling is 70%.

[c30] The method of claim 26, wherein the radial force plot comprises a chart plot of resultant radial force.

[c31] The method of claim 30, wherein the polar plot indicates that the resultant force is less than a predetermined value for a selected percentage of the time during simulated drilling.

[c32] The method of claim 31, wherein the selected percentage of time during simulated drilling is 70%.

[c33] The method of claim 26, wherein the radial force plot comprises a box-whisker plot of resultant radial force.

[c34] The method of claim 33, wherein the polar plot indicates that the resultant force is less than a predetermined value for a selected percentage of the time during simulated drilling.

[c35] The method of claim 34, wherein the selected percentage of time during simulated drilling is 70%.

[c36] The method of claim 24, further comprising adjusting bit design parameters.

[c37] The method of claim 36, wherein the drilling tool assembly comprises a roller cone drill bit; and wherein the bit design parameters comprise at least one of a group consisting of a cone profile, a cone axis offset, a number of cutting elements on each cone, a location of a cutting element of the drill bit, a size of a cutting element of the drill bit, a shape of a cutting element of the drill bit, and an orientation of a cutting element of the drill bit.

[c38] The method of claim 36, wherein the drilling tool assembly comprises a fixed cutter drill bit; and wherein the bit design parameters comprise at least one of a group consisting of a cutter location, a cutter orientation, a cutter size, a cutter shape, and a cutter bevel size, a bit profile, a bit diameter, a number of blades on the bit, a blade geometry, a blade location, a junk slot area, and a bit axial offset.

[c39] A method for designing a bit, comprising:

defining parameters for a simulation of the drill bit drilling in an earth formation, wherein the parameters comprise at least bit design parameters;

executing the defined simulation;

graphically displaying radial forces resulting from the executing of the defined simulation;

applying a criterion to the graphically displayed radial forces; and

adjusting one of the at least bit design parameters in response to the applying of the criterion.

[c40] The method of claim 39, wherein the graphically displaying occurs in real time.

[c41] A method for selecting an optimal bit design, comprising:

simulating a first bit design drilling in earth formation;

obtaining radial forces resulting from the simulating of the first bit design;

applying a criterion to the obtained radial forces of the first bit design; and

adjusting one of the at least bit design parameters in response to the applying of the criteria to the first bit design to generate a second a second bit design;

simulating the second bit design;

obtaining radial forces resulting from the simulating of the second bit design;

applying the criterion to the obtained forces of the second bit design; and

comparing the first bit design and the second bit design with respect to the criterion; and

selecting the optimal bit design of the first bit design and the second bit design.

[c42] A drill bit designed using the method of claim 1.

[c43] A bottomhole assembly designed using the method of claim 24.

[c44] A system for simulating a drill bit drilling in an earth formation, comprising

means for defining parameters for a simulation of the drill bit drilling in earth formation, wherein the parameters comprise at least bit design parameters;

means for executing the defined simulation;

means for obtaining radial forces resulting from the executing of the defined simulation;

means for applying a criterion to the obtained radial forces; and

means for adjusting one of the at least bit design parameters in response to the applying of the criterion.